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George C. Marshall Space Flight Center  
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# ORGANIZATIONAL WORK INSTRUCTION

## NONMETALLIC MATERIALS AND PROCESSES GROUP/ED34

# OPERATION PROCEDURE 5' x 9' AUTOCLAVE

## Baseline

CHECK THE MASTER LIST-  
VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

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**OPERATION PROCEDURE  
5' x 9' AUTOCLAVE**

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## OPERATION PROCEDURE 5' x 9' AUTOCLAVE

### 1.0 SCOPE

#### 1.1 Scope.

This manual covers the procedures for operating the 5' x 9' Autoclave. Only trained operators are allowed to operate this equipment. A list of all trained operators is maintained by ED34. Before operating this system, the operator should read and understand this entire working instruction.

#### 1.2 Purpose.

The purpose of this manual is to provide detailed information and instructions for the operation of the 5' X 9' Autoclave (ECN G83737) located in Building 4707, Room 128. This autoclave is a pressure vessel used for curing and bonding composite materials. This autoclave can operate within the limits of 1000°F and 500 psig. The autoclave is heated with electrical heaters and pressurized using gaseous nitrogen (GN2).

#### 1.3 Applicability.

ISO 9000 requirements apply to this instruction only to the extent that activities performed herein are "in-scope" as defined by the Marshall Management Manual.

### 2.0 APPLICABLE DOCUMENTS

1. Micristar User's Manual
2. Marshall Management Manual (MPD 1280.1)
3. General Procedure for Programming Molyteks

### 3.0 DEFINITIONS

None

### 4.0 SAFETY PRECAUTIONS AND WARNING NOTES

The operation of the 5'x9' autoclave, and its supporting activities, involve numerous hazards (refer to Section 4.2) which can result in personnel or equipment injury.

The Nonmetallic Materials and Processes Group (ED34) has the overall responsibility for the safety of autoclave operations. **However, individual operator responsibility for safety cannot be overemphasized.** All individuals involved with the 5' x 9' autoclave operations have the responsibility for adherence to

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defined safety requirements as provided by written procedures, training, and supervisory instructions.

All hazards must be immediately reported to the ED34 Lead Engineer (or their designee) for corrective action.

#### **4.1 Numbers To Call In Case Of Emergency:**

Ambulance	911	
Medical Center	4-2390	
Fire	911	
MSFC Security	4-4357	(4-HELP)
MSFC Safety	4-0046	
Facilities	4-3919	
Environmental Health	4-2390	
Emergency Operations Center	4-3131	
Environmental Accidents	4-1515	
ED34 Management Support		
Assistant	4-2715	
ED34 Lead Engineer	4-8456	

#### **4.2 Emergency Procedures**

To depressurize the autoclave in an emergency situation, please perform the following steps:

- a) Press the HOLD/RUN key to put the Micristar in HOLD.
- b) Press the HOLD/RUN key again to put the Micristar in RUN.  
**NOTE: The number in the lower display and the RUN LED will flash.**
- c) Press the INC/DEC key to choose SEGMENT 48 of the program profile.
- d) Press ENTER. **NOTE: This will put the Micristar in the shutdown segment and will depressurize the system.**

**NOTE:** In the event of a fire alarm, exit to the south personnel door of Room 128. If it is evident that a fire exists, follow the emergency procedure for fire in this Section below. If it is not evident there is a fire, stay close to the south personnel door of Room 128 until given the all-clear to resume activities. If the part is at a critical stage of the cure cycle, you may re-enter to assure part safety, but stay as close to the South Personnel door as possible and return immediately upon completing task.

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PROBLEM	CORRECTIVE ACTION
OXYGEN DEFICIENCY ALARM	<ul style="list-style-type: none"> <li>◆ Place the autoclave main power electrical breaker in the <b>OFF</b> position</li> <li>◆ Immediately leave the area</li> <li>◆ Call MSFC Security at 4-4357 (4-HELP)</li> <li>◆ Notify ED34 Lead Engineer</li> </ul>
ELECTRICAL PROBLEMS SHORT CIRCUITS	<ul style="list-style-type: none"> <li>◆ Place the autoclave main power electrical breaker in the <b>OFF</b> position</li> <li>◆ Notify ED34 Lead Engineer</li> </ul>
FIRE	<ul style="list-style-type: none"> <li>◆ Depressurize the autoclave</li> <li>◆ Place the autoclave main power electrical breaker in the <b>OFF</b> position</li> <li>◆ Evacuate the area/building and proceed to a safe location</li> <li>◆ Dial 911 to notify Fire Department</li> <li>◆ Notify ED34 Lead Engineer and NASA Safety Office Coordinator</li> </ul>
PERSONNEL INJURY	<ul style="list-style-type: none"> <li>◆ Contact the Medical Center by dialing 911</li> <li>◆ <b>DO NOT MOVE THE INJURED UNLESS ABSOLUTELY NECESSARY TO PREVENT FURTHER INJURY</b></li> <li>◆ Depressurize autoclave if required</li> <li>◆ Place the autoclave main power electrical breaker in the <b>OFF</b> position if required</li> <li>◆ Notify NASA Safety Office Coordinator</li> <li>◆ Notify ED34 Lead Engineer</li> </ul>
EMERGENCY SHUTDOWN FOR ANY OTHER REASON	<ul style="list-style-type: none"> <li>◆ Depressurize autoclave</li> <li>◆ Place the autoclave main power electrical breaker in the <b>OFF</b> position</li> <li>◆ Notify ED34 Lead Engineer</li> </ul>

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### 4.3 Significant Hazards.

Autoclave operations involve the following potential hazards:

- Autoclave door contact with personnel, parts, and tooling.
- Heated surfaces
- Heavy lifting
- High noise area
- High pressure gaseous nitrogen
- Overhead crane operation
- Oxygen deficiency environment
- Pinch points

## 5.0 INSTRUCTIONS

### 5.1 Preoperational Inspection.

Before the autoclave can be started, a visual inspection of the autoclave and its supporting subsystems must be completed. Any discrepancies must be reported to the ED34 Lead Engineer for disposition. Complete the preoperational inspection (see example in Appendix A) located in the 5' x 9' Autoclave Log Book. Before operating the system, the operator should read and understand this entire manual.

### 5.2 Autoclave Setup.

Note: This procedure assumes that the autoclave was left in the standard shut down configuration with the door fully open. Place the part inside the autoclave and follow these instructions:

1. Turn the main circuit breaker located on the control panel to the "ON" position.
2. If the "VESSEL OVERTEMP" alarm activates, check and reset the alarm.
3. At the control panel, turn the "CONTROL POWER" selector switch to the "ON" position.
4. Check, silence, and reset any alarms as necessary.
5. In the SW corner of Room 128, activate the overhead exhaust fan to provide ventilation during the cure process.
6. Start the vacuum pump by turning its selector switch (located on the control panel) to the "ON" position.
7. NOTE: The rubber coated vacuum hoses are normally used for cures below 425°F. For cures greater than 425°F, use the steel flex hoses.

With the bagged part inside the Autoclave connected to the Monitoring and Control lines with their own independent flexible hoses, open the monitoring valve and the vacuum



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source valve, (by putting them both in the "ON" position). When vacuum is required, turn the Vacuum Source control valve to the "VACUUM" position. Similarly, when it is necessary to vent the bag, turn the Vacuum Source control valve to the "VENT" position. If vacuum will not be further required, the vacuum pump may be shut off by turning its selector switch to the "OFF" position.

8. Connect the necessary thermocouples to the part.
9. Turn on the hydraulic unit by pressing the "START" button.

**NOTE:** Hydraulic levers are located on the front side of the autoclave, opposite from the door hinges.

10. Close the autoclave door by pulling or pushing the appropriately marked hydraulic valve lever. Hold this lever until the door closes.

**CAUTION:** Release the lever slowly to its neutral position. Sudden door stops may damage hydraulic system due to weight of door.

11. Once the door is fully closed, lock the autoclave door by pulling or pushing the appropriately marked hydraulic valve lever. Hold this lever until the locking ring manual lock has cleared the manual lock lever. Once the door is locked, slowly release the lever.
12. Secure the manual safety locking lever, which also de-energizes the hydraulic system.

**NOTE:** If the door does not fully lock, or requires excessive time to rotate the locking ring, unlock the door, open the door, and grease the locking wedges.

13. Shut off each vacuum line not in use with its manual ball valve.
14. Select "MANUAL" with the selector switch marked "PROCESS CONTROL".

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### 5.3 Molytek Chart Recorder

Refer to the "General Procedure for Programming Molyteks" located in the 5' x 9' Autoclave Log Book for instructions on how to operate the Molytek Chart Recorder.

### 5.4 Micristar Programming Notes.

These instructions are to aid the Autoclave Micristar programmer and assumes that the programmer is proficient in the operation of the instrument.

AUTO: When the control panel selector switch has been placed in the "AUTO" mode and the "CYCLE START" button has been pushed, the PLC starts the blower motor, vacuum pump and resin trap refrigeration units and starts the Micristar in the Program Run mode at Segment 50. This "first" Segment is used to initialize the Micristar so that the temperature and pressure profiles begin at some reasonable previous run. **DO NOT change the values in Segment 50. If it is changed then the PLC initiated program will end up with unpredictable results, and possible damage to the Autoclave and/or the parts being cured.**

After the cure cycle has been completed it is necessary to run segments 48 and 49. These 2 segments check to see that the Autoclave temperature is below 150 degrees F and the pressure is below 3 psi. If these values have not been met, the Micristar is put in "PROGRAM HOLD", and will stay there until they are met.

Once segment 48 has begun and the autoclave has been determined to be safe to turn off, the segment 49 is run which signals the PLC to turn off the blower motor, vacuum pump and the resin trap refrigerator units. This also resets the PLC in preparation for the next "AUTO" run.

The purpose for running segments 48 and 49 is to ensure that the Autoclave has actually completed the cure cycle. For example, the Autoclave has been running at 850 degrees F and 350 psi and the program told it to cool down in 3 minutes. There is no way that the Autoclave can actually meet these setpoints in the time given. However, without segments 48 and 49 in the program, the autoclave would shut down after the 3 minutes of the last segment, leaving the temperature and

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**pressure at elevated, and unsafe levels. Therefore, segments 48 and 49 act as a safety check.**

SEMI: The significant difference between SEMI (automatic) and AUTO is that the user may start the Micristar's program running at any segment, as opposed to starting only at segment 50. Since SEMI still uses the PLC to control the autoclave it is necessary to end the program with segments 48 and 49 as in the AUTO mode.

**Be sure to start the program profile with an "initialization" segment like segment 50.**

MANUAL: In MANUAL mode the Micristar can be started and ended at any segment desired. It is still necessary to start the program with an "initialization" segment as discussed above. Since there is no "shut down" signal given to the PLC it will be the operators responsibility to determine that the curing cycle is complete and that it is safe to shut down the Autoclave system.

## **5.5 Micristar Control System Programming.**

The following sequence of steps are used for programming the Micristar Control System. Two panels are utilized for this operation: the operator panel and the primary panel (see inserts in the 5' x 9' Autoclave Log Book).

**NOTE: LED indicators define all displays and prompt all key sequences on both the operator and primary interface levels. If the LED is not lit, the function can not be accessed.**

### **5.5.1 Programming The Micristar.**

1. Access the primary panel by flipping down the operator panel (front panel).
2. Verify that the Micristar is in HOLD mode (LED is lit). If RUN LED is lit, press the HOLD/RUN key once.
3. Verify that the Micristar is in AUTO mode. If the Micristar is in MANUAL mode, press the MANUAL/AUTO key.

**NOTE: Full Access is required to program the Micristar. To obtain Full Access, follow steps 4 and 5.**

4. Press the RI logo.

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5. Press the hidden key #1.

**NOTE: You are now in Full Access mode. The program can now be entered using the Micristar Programmer tables.**

6. Press PGMR TABLES key to activate the programmer table functions.
7. When the PGMR TABLES function is first accessed, SEGMENT (SEG) is selected and "1" (Segment 1) is shown in the lower display.
8. Press the down SCROLL key **once** to select the SETPOINT.
9. Press the FAST INC/DEC (INCREMENT/DECREMENT) and INC/DEC keys until the desired set point is shown in the lower display.
10. Press the down SCROLL key until SEG TIME LED is lit.
11. Press the ENTER key once. Note that the left-most field is blinking. (00.00.00 represents the hours, minutes, and seconds, respectively).
12. Use the FAST INC/DEC and the INC/DEC keys to select the desired hours.
13. Press the ENTER key. The second pair of zeros will blink.
14. Use the FAST INC/DEC and the INC/DEC keys to select the desired minutes.
15. Press the ENTER key, and use the INC/DEC keys to enter the number of seconds.
16. Press the ENTER key to complete this portion.
17. Press the down SCROLL key to select NEXT SEG.
18. Use the INC/DEC keys until the number corresponds to the segment you wish for the program to go. **NOTE: This number is usually the next consecutive number to the current segment.**
19. Press the SCROLL key to select SEGMENT.
20. Use the INC/DEC key to select the next segment for the program.
21. Repeat steps 7 - 18 until you have completed the program.

**NOTE: When programming the last segment in your profile, the NEXT SEGMENT should be SEGMENT 48. This segment will send the autoclave into a shutdown mode at the completion of the cure cycle.**

## **5.6 Energizing the Subsystems.**

With the appropriately marked push-button, energize the blower.

## **5.7 Starting The Micristar.**

1. Review your program as follows:
  - a) Press PGMR TABLES. Segment 1 will appear.

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- b) Press the SCROLL key to review the profile for that segment.
  - c) Scroll to the SEGMENT option.
  - d) Press the INC/DEC key to choose the next segment you wish to review.
  - e) Repeat steps b-d until complete.
2. Close the operator panel.
  3. Press the HOLD/RUN key.
  4. The number in the lower display and the RUN LED will flash.

**NOTE:** This flashing number is the starting segment and should be segment 50. If this number does not correspond to the starting segment, press the INC/DEC key to choose the correct number (50).

5. Press ENTER.

**\*\*\*\*\* THE MICRISTAR IS NOW RUNNING \*\*\*\*\***

### **5.8 Monitor The Autoclave.**

Monitor the cure throughout the cycle to verify proper operation.

**Note:** The autoclave will continue to operate until the Micristar controller's cure cycle is complete. A single operator may perform the monitoring function during regular work hours if periodic contact (verbal or visual) is established between the lone operator and other employees to ensure the operator's safety. A minimum of two operators are required to monitor the autoclave during overtime hours.

**Note:** If positive pressure is sensed in any of the monitoring or source lines, a warning lamp will light and automatic valves will shut off the respective sub-systems from over-pressure damage. It is important for the operator to note which source AND monitoring lines are being used on each bagged part. If any of the lines to a particular part show any signs of positive pressure, (as shown on the warning light indicators or the data logger), it is the operators responsibility to turn off ALL manual valves associated with that station.

#### **5.8.1 Using The Operator Panel Once Program Is Running.**

To check the set point (SP), process variable (PV), or segment during the run, use the SCROLL key. The value will be shown in the lower display. The upper display will also show the set

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point (SP) and the process variable (PV) by using the arrow keys in the upper right-hand corner.

1. Review your program as follows:

- a) Flip down the operator panel.
- b) Press PGMR TABLES. Segment 1 will appear.
- c) Press the SCROLL key to review the profile for that segment.
- d) Scroll to the segment option.
- e) Press the INC/DEC key to choose the next segment you wish to review.
- f) Repeat c-e until complete.

2. To change your setpoint during the run:

- a) Flip down the operator panel.
- b) Put the Micristar on HOLD.
- c) Press the RI logo. (see Appendix G)
- d) Press the Hidden Key #1. (see Appendix G)
- e) Press the PGMR key.
- f) SCROLL to the SETPOINT.
- g) Press ENTER.
- h) Use INC/DEC keys to change the setpoint.
- i) Close the operator panel.
- j) Press the HOLD/RUN key to put the Micristar back in RUN mode.

**NOTE: The number in the lower display will flash.**

- k) Press the INC/DEC key to choose the correct segment value that you want to start.

3. Press ENTER.

4. To hold the program in its current segment: Press the HOLD/RUN key to put the Micristar in HOLD. NOTE: This will hold the temperature and pressure at the present value.

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## 5.9 Shutdown Procedures

**Before shutdown procedures can begin, two autoclave operators must be present due to the danger of exposure to GN2.**

When the cure cycle is over and the part has cooled to below 150°F (or cooled below the cure cycle's recommended venting temperature), perform the following steps:

### 5.9.1 Stopping The Micristar.

The Micristar is programmed to shutdown the system in the last two segments of the program (Segments 48 and 49). However, if for some reason the program needs to be halted during the cure, follow these instructions:

- a) Press the HOLD/RUN key to put the Micristar in HOLD.
- b) Press the HOLD/RUN key again to put the Micristar in RUN.  
**NOTE: The number in the lower display and the RUN LED will flash.**
- c) Press the INC/DEC key to choose SEGMENT 48 of the program profile.
- d) Press ENTER. **NOTE: This will put the Micristar in the shutdown segment.**

### 5.9.2 Partially Open The Autoclave Door.

#### **WARNING: DOOR HAZARD**

Prior to opening the autoclave door, verify that no personnel are in the path of the door. A possibility exists of personnel being trapped between the two autoclave doors.

Before opening the autoclave door after pressurization:

1. Verify that the autoclave has zero pressure registering on the Micristar controller.
2. Open the south personnel exit door in Room 128 to enhance ventilation.
3. Verify that the overhead exhaust fan is operating. The fan must be operating to ensure adequate ventilation is maintained in the area while the autoclave door is opened.
4. Activate the hydraulic pump by pressing its "START" button.

**WARNING: Potential oxygen deficient atmosphere is possible due to excess GN2 leaving the autoclave through the open door. An oxygen deficient atmosphere can cause dizziness, loss of consciousness, or death. Utilize the buddy system when working in the autoclave area when the autoclave door is open. Should**

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the oxygen deficiency alarm activate, shut down the autoclave, have all personnel immediately leave the area, and call security at 4-4357 (4-help) to notify them of the incident.

5. To Unlock the Autoclave Door:

- a) Open manual safety locking lever -- this lever prevents energization of the hydraulic system.
- b) Push or pull appropriately marked hydraulic valve lever, and hold until door locking lugs are fully visible through the cutouts in the locking ring.
- c) Slowly release locking lever.

**NOTE:** Hydraulic levers are located on the front side of the autoclave, opposite from the door hinges.

6. Open the autoclave door by pushing or pulling the appropriately marked hydraulic valve lever, and hold while door opens.

**CAUTION:** Release the lever slowly to its neutral position. Sudden door stops may damage hydraulic system due to weight of door.

7. Turn off the hydraulic pump by pushing its "STOP" button.
8. Leave the immediate area for at least five minutes to allow the nitrogen gas to dissipate.
9. Verify that the temperature inside the autoclave is less than 150°F.
10. Disconnect all vacuum hoses and thermocouples from the part. Verify that all vacuum hoses and thermocouples are returned where they belong. Remove the part from the autoclave.
11. Turn off the blower by pressing its "STOP" button.
12. Turn off the vacuum system selector switch.
13. Turn off the CONTROL POWER switch.
14. Turn off the main circuit breaker.

### **5.9.3 Perform Post Operational Inspection.**

1. Perform the post operational inspection (see example in Appendix B) located in the 5' x 9' Autoclave Log Book.
2. Complete the Log Book Data Sheet (see example in Appendix C) located in the 5' x 9' Autoclave Log Book. Note in the Comment section any problems that were encountered during the cure.



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3. Refer to Section 8.0 of this procedure if your task is in-scope as defined by ISO9000. You must maintain quality records.

## 6.0 NOTES

### 6.1 Responsibility.

The Nonmetallic Materials and Processes Group (ED34) has the prime responsibility for maintaining the safe operating condition, and configuration control of this autoclave. Any organization requesting to use this autoclave must be trained and must schedule all work on the calendar provided at the autoclave. All work performed on this autoclave or its supporting subsystems must be coordinated through ED34 so configuration control of the autoclave can be maintained. Any changes or updates to this procedure must also be coordinated through ED34. It is the responsibility of the ED34 Lead Engineer (or designee) to:

- Assure that appropriate safety equipment is available as required by MSFC procedures.
- Perform random walk-throughs to confirm that only trained personnel are monitoring the operation; operating the autoclave control system, and to confirm that access control to the autoclave work area is being followed when the autoclave is pressurized.

## 7.0 APPENDICES, DATA, REPORTS, AND FORMS

Appendix A: 5' x 9' Autoclave Preoperational Inspection Sheet  
Appendix B: 5' x 9' Autoclave Post-Operational Inspection Sheet  
Appendix C: 5' x 9' Autoclave Log Book Data Sheet  
Appendix D: 5' x 9' Autoclave Safety Features

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## 8.0 QUALITY RECORDS

Quality records for this system will be maintained for all in-scope work by ED34 for the duration of the project plus three years. **If a cure is part of an in-scope project, the operator is responsible for completing the following list:**

- Complete the ED34 Inspection, Measuring, & Test Equipment (IM&TE) In-Scope Activities Traceability Log located in the Usage Log Book.
- Make two (2) copies of each of the following:
  - 5' x 9' Autoclave Preoperational Inspection Sheet
  - 5' x 9' Autoclave Post Operational Inspection Sheet
  - Data Log Users Form
- Give one copy to the lead engineer for the in-scope project
- Give the second copy to the applicable ED34 Management Support Assistance (Building 4712, Room B206)
- Return the original's to the User's Log Book located in the autoclave area

Training Records and Calibration Lists associated with in-scope work will also be maintained by ED34. Training records will be maintained as long as the employee is performing in-scope work. Calibration records will be maintained and replaced only with current information.

All Quality Records, if applicable, will be maintained by ED34.

## 9.0 TOOLS, EQUIPMENT, AND MATERIALS

None

## 10.0 PERSONNEL TRAINING

Prior to any training sessions, contact ED34 for approval. The trainee, at this time, will be given a training record sheet to maintain and update throughout the training process. Any personnel using this system to perform in-scope work must be authorized by ED34. A list of authorized users is maintained by ED34. The requirements for training are listed below. Authorization will be given by ED34 after completion of all training requirements. Careless or unsafe operation of this autoclave may result in the suspension of the operator's authorization.

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Current autoclave training consists of the completion of the following curriculum:

- Training and Certification for overhead crane operations by the NASA Safety Office Coordinator (as required).
- Training and Certification for fork truck operations by the NASA Safety Office Coordinator (as required).
- The trainee must also complete On the Job Training (OJT) for a minimum of four autoclave operations. Additional OJT may be required until the trainee demonstrates safe and proficient operation of the equipment, and understanding of the proper safety procedures associated. The training may be performed by any trained operator, however, approval of any training session must be authorized by ED34. Contact the ED34 Lead Engineer prior to the fourth OJT cure. A final audit for the authorization process will be performed at this time.

**For all newly trained contractor employees**, ED34 must have on file, a memo from the employee's supervisor stating that the employee has completed all requirements called out in this instruction and a signed copy of the Training Record Sheet to operate this equipment. Once the memo has been received by ED34, approval will be given following review.

#### 11.0 FLOW DIAGRAM

None

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**APPENDIX A: 5' x 9' Autoclave Preoperational Inspection Sheet**

Date: \_\_\_\_\_

Cycle: \_\_\_\_\_

**Operator**

**1.0 Inspect Safety Equipment**

**Initials:**

A.	Verify that the proper safety equipment is available	
	1. Leather gloves	
	2. Fire extinguisher	
	3. Hearing protection	
	4. Eye Protection	
B.	Verify that the calibration dates are valid/current for the following items:	
	Molytek Part Temperature Chart Recorder - 676478	
	Molytek System Temp/Press and Part Temp Recorder - 676476	
	Pressure Gauge - B98-3155-A	
	System Pressure transducer	
	Micristar Controller	
	Vacuum Transducers	
	System Overtemp	
	Vessel Jacket Overtemp	
C.	Post "NOTICE: Authorized Personnel Only" signs to limit access to the autoclave area during autoclave operations (Room 129A Double Doors, Room 128, and one each on the north and south doors of Room 128.)	

**Operator**

**2.0 Inspect Autoclave Subsystems**

**Initials:**

A.	Verify proper control panel operation	
	1. Verify proper digital display on the chart recorder	
	2. Verify Micristar controller is functioning properly	
	3. Verify adequate paper supply for the chart recorder	
B.	Verify vacuum pump is operational (if required)	
	1. Verify the vacuum pump is turned on and running.	
	2. Check vacuum pump oil level.	
	3. Inspect for any leaking vacuum oil.	
C.	Ensure that the plant cooling water supply system is operating properly.	
D.	Verify overhead exhaust fan is operational.	

**Operator**

**3.0 Visual Inspections**

**Initials:**

A.	Inspect the autoclave door O-ring seal to verify that there are no damaged areas that would affect the seal of the door to the autoclave.	
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# APPENDIX B

## 5' x 9' Autoclave Post-operational Inspection Sheet

Date: \_\_\_\_\_

Cycle: \_\_\_\_\_

Operation		Operator Initials
1.	Verify that the safety equipment is put away.	
2.	Verify that the autoclave door is in the open position.	
3.	Verify that the thermocouples are put away.	
4.	Verify that the vacuum hoses are put away.	
5.	With the vacuum valve open, verify that the vacuum lines inside the autoclave have proper flow using the vacuum line test fitting. Close the vacuum valve.	
6.	Verify that the vacuum valves are in the Closed position.	
7.	Verify that the vacuum pump oil level is sufficient.	
8.	Turn off the Control Power by using its selector switch.	
9.	Verify the autoclave, chart recorder, and Micristar are all off.	
10.	Verify the MAIN PWR disconnect is in the "OFF" position.	
11.	Verify that the cure cycle information form, the preoperational inspection form, and the post operation inspection form are properly filled out and entered into the log book.	

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## APPENDIX C

### 5' x 9' Autoclave Log Book Data Sheet

Please include first and last name:

Operators: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Date: \_\_\_\_\_

Organization: \_\_\_\_\_

Cure Cycle Number: \_\_\_\_\_

Purpose/Description of cure:

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Maximum temperature: \_\_\_\_\_ degrees F

Total time at maximum temperature: \_\_\_\_\_

Maximum pressure: \_\_\_\_\_ psig

Total time at maximum pressure: \_\_\_\_\_

Preoperational inspection completed by: \_\_\_\_\_

Postoperational inspection completed by: \_\_\_\_\_

Comments:

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## APPENDIX D

### 5' x 9' Autoclave Safety Features

#### D.1. Manual Door Safety Interlocks.

The autoclave is equipped with the Harris Quick Opening Door. This door features mechanical and electrical safety devices and interlocks to prevent opening the door while the autoclave is under pressure.

A "MANUAL DOOR SAFETY INTERLOCK", as required by the ASME Pressure Vessel Code, is provided on the vessel door. The locking lever of the mechanism, through a connecting rod, operates a ball valve which is plumbed to the interior of the vessel. Located on the connecting rod is a cam for the operation of a limit switch. Also part of the mechanism is a pneumatic cylinder located on the side, which is also plumbed to the vessel interior. Energized by vessel pressure, the cylinder rod extends through the lever to hold it in the locked position when the vessel is pressurized.

When the Mechanism is "locked":

- The limit switch disables the hydraulic system.
- The limit switch enables the pressurizing system.
- The ball valve to vessel interior is closed.

When the Mechanism is "unlocked":

- The limit switch enables the hydraulic system, provided the LOW PRESSURE SWITCH (see D.2 is not still pressurized.
- The limit switch disables the pressurizing system.

#### D.2. Low Pressure Switch.

A "Low Pressure Switch" is plumbed to the vessel interior and wired into the hydraulic system. When the vessel is pressurized the switch disables the system until pressure returns to a level below the setpoint of the switch (3 psig decreasing.)

#### D.3. Mechanical Over-Pressure Protection.

Any "OVER-PRESSURE" condition will be rectified by built-in safety devices.

If the vessel pressure exceeds the maximum operating pressure of the Autoclave, an ASME Code safety relief valve will automatically open to reduce pressure. If the condition is

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corrected by the safety relief valve, it will reset and shut off at some pressure level lower than the set pressure level.

If pressure continues to increase to a second, higher limit, a rupture disc will open and allow all pressure media to escape. Once the rupture disc opens it is destroyed and has to be replaced with a new disc with the same specifications.

#### **D.4. Safety Feature With Alarms.**

**CAUTION:** Alarm situations will require immediate action by the autoclave operator and may require additional action by other qualified personnel. Hazardous voltage, temperature and pressure may be present at areas requiring servicing, therefore, only fully qualified personnel, with thorough understanding of autoclaves and component functions and integration should be utilized for trouble shooting.

All alarm conditions will put the Micristar in PROGRAM HOLD if operating in the AUTO or SEMI modes and will stay in hold until the alarm condition has cleared.

##### **D.4.1 Man Inside.**

A "MAN INSIDE" alarm is incorporated into the control system and consists of a cable running the length of the work zone, inside the autoclave. Pulling the cable:

- Sounds an audible alarm.
- Activates a "red" alarm light.
- Disables the pressurization system and vents the Autoclave.
- Disables the heating system.
- Turns off the recirculation blower.
- Allows the hydraulic system to be operated to open the autoclave door.

The operator may silence the alarm horn by pressing the "RESET" push-button on the control panel. The autoclave door must be opened to reset the alarm circuitry by repositioning the linkage of the "MAN INSIDE" alarm located midway down the work zone.

**NOTE:** The electrical circuitry of the MAN INSIDE ALARM includes a heating circuit "SHUNT TRIP" circuit breaker and will need to be reset from inside the electrical control panel by a qualified electrician. If this breaker requires resetting, contact the ED34 Lead Engineer for disposition. DO NOT attempt to reset this breaker.



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#### **D.4.2 Vessel Over-Temperature.**

The "VESSEL OVER-TEMPERATURE" controller is an independent safety device designed for the protection of the Autoclave heating equipment only and is not intended for protection of the load being cured. The controller measures temperature at the hottest point in the autoclave and, therefore, the setpoint of the device should be set approximately 100 degrees F higher than the maximum Autoclave operating temperature.

"OVER-TEMP" condition:

- Sounds an audible alarm.
- Activates a "red" alarm light.
- Disables the heating system.

The operator may silence the alarm by pressing the "RESET" push-button. The "OVER-TEMP" control device will need to be reset by pushing it's reset button.

**NOTE:** The electrical circuitry of the "VESSEL OVER-TEMPERATURE" alarm includes a heating circuit "SHUNT TRIP" circuit breaker and will need to be reset from inside the electrical control panel by a qualified electrician. If this breaker requires resetting, contact the ED34 Lead Engineer for disposition. DO NOT attempt to reset this breaker.

Possible causes:

- Over-temp control device set point too low.
- Over-temp control device thermocouple failure.
- Temperature controller malfunction: change in configuration parameter, PID settings, I/O circuitry.
- Calibration of temperature controller and/or over-temp device.

#### **D.4.3 No Subsystem Cool.**

With the high temperatures that are possible with this Autoclave, special cooling provisions are necessary.

The main blower motor is externally mounted and drives the blower fan shaft by means of belts and sheaves. The blower shaft utilizes a "packing" to maintain vessel pressure. To prevent damage due to excess temperature the blower shaft and packing gland is water cooled and requires water to circulate whenever in operation. The door seal itself is also water cooled and uses the same cooling water source as the blower shaft circuit described above.

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The pressure vessel is also fully water jacketed, which is, essentially, a complete, separate, external pressure vessel. Cooling water is circulated inside the water jacket which will keep the main pressure vessel temperature at a safe level.

A flow switch is utilized on the Subsystem Cooling water return line. Loss of water flow through the flow switch causes the flowing alarm condition.

"NO SUBSYSTEM COOL" - NO FLOW condition:

- Sounds an audible alarm.
- Activates a "red" alarm light.

The operator may NOT silence the alarm by pushing the "RESET" push-button. This alarm does NOT disable the blower motor so it allows the Autoclave operator to decide to continue with the current run and risk equipment failure or abort the curing cycle.

**NOTE: The alarm will remain on until water flow resumes through the cooling circuit.**

The same alarm is also utilized by the "VESSEL JACKET COOLING OVERTEMP CONTROLLER". The Autoclave vessel cooling jacket water temperature is monitored to ensure that safe vessel wall temperatures are maintained. A seven position rotary switch is provided to monitor the six separate water channels of the cooling jacket. The number of the rotary switch position corresponds with the location and number of the cooling jackets.

**NOTE: Channel 0 is an open channel for testing of the alarm circuit and switching to this position will activate the alarm.**

The thermocouple signal that has been selected by the rotary switch is then set to the over-temp device. With the setpoint of the device set at 200 degrees F, the alarm will sound any time the water temperature reaches that point.

"NO SUBSYSTEM COOL" - JACKET COOLING OVERTEMP condition:

- Sounds an audible alarm.
- Activates a "red" alarm light.
- Disables the heating system.

The operator may NOT silence the alarm by pushing the "RESET" push-button. The "VESSEL JACKET COOLING OVERTEMP CONTROLLER" must be reset after the over temperature source has been resolved.

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**NOTE:** The electrical circuitry of the "VESSEL JACKET COOLING OVERTEMP CONTROLLER" alarm includes a heating circuit "SHUNT TRIP" circuit breaker and will need to be reset from inside the electrical control panel by a qualified electrician. If this breaker requires resetting, contact the ED34 Lead Engineer for disposition. DO NOT attempt to reset this breaker.

#### **D.5. Temperature.**

The temperature of the autoclave platen is normally lowered to below 150 degrees F prior to its removal from the autoclave. This is not a dangerously high temperature, however, precautions should be taken to prevent possible burns. If for some reason the platen must be removed before reaching 150 degrees F or lower, personnel should protect their hands by using Zetex gloves (or equivalent).

#### **D.6. Pressure.**

The autoclave can be operated at pressures up to 500 psig. The volume of compressed gas at this pressure is capable of transferring tremendous energy should there be a failure which results in a rupture. Extra caution should be taken while operating this autoclave.

#### **D.7. Vacuum System Operation.**

The vacuum system provided for this autoclave consists of 2 subsystems. The Vacuum Monitoring and the Vacuum Control Systems. All user controls are located on two vacuum panels.

##### **VACUUM MONITORING SYSTEM:**

A flexible vacuum hose connects the bagged parts to the monitoring system inside the Autoclave. The 16 vacuum transducers are wired to a recording data logger with an isolating ball valve used to shut off each transducer when not in use. These manual valves are marked "Vacuum Monitor ON-OFF". In the ON position the part inside the Autoclave is connected through to the vacuum transducer. In the OFF position the part is isolated from the monitoring equipment. An automatic sensing circuit is built in that will shut off the monitoring equipment should positive pressure develop indicated a bag leak inside the Autoclave. If this condition occurs an indicator lamp will light on the electrical control panel.

##### **VACUUM CONTROL:**

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A flexible hose connects the bagged parts to the vacuum control system inside the autoclave. Each of the 16 vacuum control stations are individually connected to the vacuum source and can be opened (vented) to atmosphere with the manual 3 position valve marked "Vacuum Source VACUUM-OFF-VENT". The bagged part can be evacuated by turning the valve to VACUUM and vented to atmosphere by turning the valve to VENT. When neither condition is desired leave the valve in the OFF position. As with the Vacuum Monitoring sub-system, the Vacuum Source sub-system has bag break indication and automatic shut off. Should positive pressure develop inside the Source sub-system a numbered warning light will go on.

#### ALARM:

As described above this vacuum system is designed with automatic bag break shut off valves and indication. If positive pressure is sensed in any of the monitoring or source lines a warning lamp will light and automatic valves will shut off the respective sub-systems from over-pressure damage. It is important for the operator to note which source and monitoring lines are being used on each bagged part. If any of the lines to a particular part show any signs of positive pressure, (as shown on the warning light indicators or the data logger), it is the operators responsibility to turn off all manual valves associated with that station.

#### OPERATION:

Check oil level in vacuum pump. Add oil if necessary. Start the vacuum pump with its "Start" selector switch on the control panel. With the bagged part inside the Autoclave connected to the Monitoring and Control lines with their own independent flexible hoses, open the monitoring valve and the vacuum source valve, (by putting them both in the "ON" position). When vacuum is required, turn the Vacuum Source control valve to the "VACUUM" position. Similarly, when it is necessary to vent the bag, turn the Vacuum Source control valve to the "VENT" position. If vacuum will not be further required, the vacuum pump may be shut off with it's "STOP" selector switch.

#### RESIN TRAP:

A resin trap is provided to trap resin vapors and prevent them from entering the vacuum pump. It is recommended to check and clean out the resin traps as often as required by removing the "Pot" located beside each of the vacuum control panels. The "Pot" can be removed by loosening the 8 hex bolts on the flange

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portion of the trap and carefully lowering the removable section. Clean the condensable as required and clean the sealing O-Ring surface. The O-Ring should be lightly lubricated with a compatible grease prior to reassembling the resin trap.

#### **D.8. Vessel Penetrations.**

Pressure Inlet and Outlet  
Cooling Inlet and Outlet  
Safety Relief Outlet  
Rupture Disc Outlet  
Pressure Transducer  
32 Vacuum Penetrations  
Pressure Gauge  
Hi Limit Thermocouple Outlet  
32 Process Thermocouple Outlets  
Spares

#### **D.9. Quick Opening Door**

Breech Lock Type  
Hydraulically actuated Locking Ring  
Safety Pressure Switch utilizing vessel pressure to disable hydraulic pump and prevent lock ring rotation  
Pneumatic/Mechanical safety Locking Device utilizing vessel pressure to mechanically prevent rotation of locking ring  
Water Cooled Door Gasket

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#### **D.10. Support Saddles**

The saddles are capable of supporting the Autoclave and a maximum part load of 10,000 pounds.

#### **D.11. Internal Product Support Tracks**

The tracks are capable of supporting a maximum distributed load of 5,000 pounds. Location of tracks are designed to allow maximum utilization of available space.

#### **D.12. Insulation**

The internally applied insulation is applied with 20 gage stainless steel sheet metal sheathing.

#### **D.13. Gas Circulating System**

The gas circulation fan motor is externally mounted and sized to maintain a uniform temperature throughout the vessel within plus or minus 5 degrees F at 500 PSI and 1000 degrees F.

A 50 HP motor drives a backward curved blower wheel for 2340 CFM, 13.25 changes/ minute in empty work zone. The fan shaft is water cooled in packing gland for sealing pressure.

The gas circulation duct work is 16 gage stainless steel sheet metal adequately supported for rigidity and to prevent buckling as a result of autoclave cycling conditions.

#### **D.14. Heating And Cooling Systems**

The heaters are electrical and sized for an average heat-up rate of 5 degrees F/minute from ambient to 1000 degrees F equipped with 100 % SCR Power Controller. 145KW electric heaters are provided. 200 amp Power-Trol SCR (3 let, 3 fuse) for heating control.

The internal cooling coils are stainless steel and sized for a cool-down rate of 5 degrees F/minute from 1000 degrees F to 140 degrees F.

The 304 stainless steel cooling coil will allow 150 gpm water flow. Flexible metal hoses allow the coil to expand and contract without stressing on thermal expansion and contraction. Control and drain valves are provided. Cooling valves are provided for time proportional control of cooling.

Cooling is accomplished by using industrial water.

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#### **D.15. Controls**

The temperature and pressure controller is a Research Inc. Micristar 828 Microprocessor with two channel ramp/soak program capability with a Research Inc. 100% SCR Power Controller.

A Honeywell Dialatrol high limit temperature controller is used in conjunction with the heater power contractors to disable the heating elements in case of a controller malfunction.

An Allen-Bradley Programmable Logic Controller is provided with the following features:

- Interprets the position of operator devices
- Status of setpoint programmer events
- Temperature and pressure controller deviations and alarm status
- Motor Starter/Contractor status
- Three modes of system operation
  - Fully automatic
  - Semi-automatic
  - Manual
- Sole regulated power supply - 24 VDC
- Two general electric panel meters:
  - Circulating Fan Motor - Amperes
  - Heater SCR - % average power
- Allen-Bradley 800 Series oil-tight operator devices
- Alarm Horn

Two Molytek Chart Recorders for recording (1 - 30 channel and 1 - 22 channel):

- 32 Part temperatures
- 16 Vacuum pressures
- Autoclave temperature
- Autoclave pressure

#### **D.16. Vacuum System**

Sixteen source lines of 0.5" diameter stainless steel tubing.

Each line equipped with a manual 3 way valve for suction, off and vent to atmosphere located on the control panel, and a pressure switch and solenoid valve for automatic line shut off in the even of a bag break.

Two manifold (8 lines each) each manifold equipped with a Resin Trap.

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#### Automatic Venting

Sixteen pressure sensing lines of 0.5" diameter stainless steel tubing.

Each line is equipped with a Vacuum Transducer, pressure switch, and solenoid valve for automatic line shut off in the event of a bag break.

A Vacuum Pump operating at 100 SCFM with a 60 gallon surge tank

#### D.17. Thermocouples

- Jack panel - 32 channel interior, Type "J", female with Male Jacks.
- Junction Box - Exterior with Thermocouple Extension Wires to recorder.

#### D.18. Autoclave Control System

This Autoclave makes use of a Research Inc., Micristar 828D Programmable Controller to control system process variables.

The Micristar is integrated with a Programmable Logic controller, PLC, to provide four different modes of operation. On the control panel is a "PROCESS CONTROL" selector switch marked "AUTO-MANUAL-SEMI" which is used to provide the operator with a variety of options for running the Autoclave.

Channel #1 of the Micristar is set-up "bi-modally" to control temperature in the chamber and the input is a "J" thermocouple probe. The "reverse acting", or heating, Analog Output #1 is a proportional 4 - 20mA signal, while the "direct acting", or cooling, output is a time-proportioned relay output. The time proportioned cooling signal operates the solenoid valves a portion of the time. As an example, 60% cooling will allow cooling water to flow through the Autoclave 60% of the user configured time cycle, (usually 6.4 seconds).

The electric heaters are operated by utilizing a Silicon Control Rectifier, SCR, which incorporates a "firing circuit" interlock. For the SCR to "fire", the blower motor must be energized, which ensures proper air circulation over the heater to prevent possible element burnout.

When the Micristar calls for heat, Analog Output #1 sends the 4 - 20 mA control signal to the heater SCR control. A 20 mA signal will produce full (100%) heat input, while proportionally lower signals causes less heat input. With 4 mA, or less, 0% heat input is produced.



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When the Micristar calls for cooling, the relay outputs to a control relay which turns on both the "normally-closed" Cooling solenoid valve, causing the valve to open, and the "normally-open" cooling coil drain solenoid valve, causing the valve to close.

If the temperature is above the setpoint of the channel 1 HI-PV alarm (set at 500 degrees F) the alarm will activate so that before the cooling solenoid valve will come on, the Mist cooling system will be activated. If the cooling is on long enough to time out then the main cooling is activated.

The Mist Cooling System consists of a water solenoid valve with flow control and an air solenoid valve, plumbed into a mist mixing unit which causes the air and water to mix and enter the coil as a mist. A gauge is provided down stream of the water solenoid valve and an air regulator before the air solenoid valve so that the air and water pressure can be set a equal levels. If needed the flow control on the water solenoid valve can be adjusted to regulate water flow.

After exiting the top of the cooling coil the water returns to the cooling supply system. When cooling is no longer required the cooling or mist cooling solenoid valves and the cooling coil drain solenoid valve allow any water trapped in the coil to drain out to avoid the generation of steam within the cooling coil.

Channel #2 of the Micristar is configured "reverse-acting" to control pressure in the chamber and the input is a 4 - 20 mA signal from the pressure transducer. The analog Output utilizes a 4 - 20 mA signal.

When the Micristar calls for pressure, analog output sends the 4 - 20 mA signal to the split range pressure control valves. With the pressure control signal at 4 mA (0% output), or less, the pressure exhaust valve is fully open and the pressure inlet valve is completely closed. As control current increases, the pressure exhaust valves closes to where, at 12 mA (50% output), both pressure exhaust and inlet valves are closed. This condition occurs at setpoint. A further increase in control current will not affect the pressure exhaust valve further, however, the pressure inlet valve will begin to open and will be fully open at 20mA (100% output).

Pressure valve functions:

- 1-12 mA signal - Pressure exhaust valve closes 0 - 100%.

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- 12 mA signal - Pressure exhaust valve closed, Pressure inlet valve closed.
- 12-20 mA signal - Pressure inlet valve opens 0 - 100 %

**NOTE:** The design of the pressure control system is such that loss of either control air or electrical control signal will cause the valves to go to their fail safe positions which will open the pressure exhaust valve and close the pressure inlet valve.

#### **D.19. Miscellaneous**

The exterior of all equipment is primed and painted with an appropriate high temperature, solvent resistant polyurethane.

The autoclave is operated from a single point electrical connection of 480 VAC, 3 phase, 60 Hz power source to control cabinet. Control power derived from this source is 115 VAC.

Honeywell Air Operated Pressure Control Valves are provided to control within +/- 2 psig.

#### **D.20. Pressurized GN2**

The autoclave is pressurized with GN2, therefore, the exhaust fan on the exterior wall should be on when autoclave door is open, and doors to outside of building should also be opened.

**NOTE:** Although there is an oxygen deficiency alarm in the room, to be sure there is sufficient oxygen, always turn on the overhead exhaust fan. The overhead exhaust fan switch is located on the autoclave room west wall, adjacent to the fire extinguisher.